FORM PTO-1390 (REV 10-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: Polyganics-1(P22294US00)

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 09/701622

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/NL99/00352	04 June 1999	05 June 1998

TITLE OF INVENTION: BIOMEDICAL POLYURETHANE, ITS PREPARATION AND USE

APPLICANT(S) FOR DO/EO/US: SPANNS, Coenraad Jan; DE GROOT, Jacqueline Hermina; DEKENS, Folkert Gerhardus; PENNINGS, Albert Johan

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [x] This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f))
4. [x] The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. [x] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [x] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [x] Other items or information: postcard receipt, Application Data Sheet, cover letter (2 pps.), Notification of Transmittal of the International Preliminary Examination Report (1 pp.) and International Preliminary Examination Report with one amended page (8 pps.) and copy of International Publication Number WO 99/64491 including one (1) drawing sheet

529 Rec'd PCT/PTC 01 DEC2000

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/701622	PCT/NL99/00352	Polyganics-1(P22294US

17. [X] The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**

	CALCULATIONS (00) PTO USE ONLY	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 00.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	17 - 20 =	0	X **$18.00**	$ 00.00	
Independent claims	6 - 3 =	3	X **$80.00**	$ 240.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		0	+ **$270.00**	$ 00.00	
TOTAL OF ABOVE CALCULATIONS =				$ 1,100.00	
[X] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				$ 550.00	
SUBTOTAL =				$ 550.00	
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TOTAL NATIONAL FEE =				$ 550.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 00.00	
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a. [X] A check in the amount of $ 550.00 to cover the above fees is enclosed.

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NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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(POLYGANICS1TRANS/88:ca)

IN THE UNITED STATES
RECEIVING OFFICE (RO/US)

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DE GROOT, Jacqueline Hermina;
DEKENS, Folkert Gerhardus;
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International Application No.: **PCT/NL99/00352**

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Atty. Doc.: **Polyganics-1(P22294US00)**

Title: **BIOMEDICAL POLYURETHANE, ITS PREPARATION AND USE**

COMMISSIONER FOR PATENTS
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Washington, D. C. 20231

S I R:

PRELIMINARY AMENDMENT

Please amend the above-identified patent application which is simultaneously filed herewith, as follows:

IN THE CLAIMS-

To facilitate entry of the following changes, the Applicants have also submitted herewith substitute pages providing all the pending claims, as they now stand.

Delete claims 1-16 and substitute therefore the following claims:

--17. Biomedical polyurethane based on diisocyanate linked polyester polymer and diol components, said diol component having a uniform block-length.

18. Biomedical polyurethane according to claim 17, having the following formula:

$$\{A-B-C-B\}_n$$

wherein the B denotes diisocyanate moieties, A denotes a polyester moiety, C denotes a diol moiety and n is the number of recurring units.

19. Biomedical polyurethane according to claim 17 consisting of repeating units of the following formula

$$\{C(O)-NH-R_1-NH-C(O)-O-D-O-C(O)-NH-R_1-NH-C(O)-O-E-O\}_n,$$

wherein R_1 is an n-butylene moiety, D is a polyester moiety, E is an n-butylene diol, an n-hexylene diol or a diethylene glycol based moiety and n indicates the number of repeating units.

20. Polyurethane according to claim 17, wherein E is diol or an XYX reaction product of diol (X) and 1,4-butane-diisocyanate (Y).

21. Polyurethane according to claim 17, wherein the blocklength is the same for at least 90%, more in particular at least 98% of the diol units.

22. Polyurethane according to claim 17, wherein the polyester is based on a polyester prepared by ringopening polymerization, preferably a random copolyester.

23. Polyurethane according to claim 22, wherein the random copolyester is a copolyester of lactide, glycolide, trimethylene carbonate and/or ε-caprolacton.

24. Polyurethane according to claim 17, wherein the polyester is based on lactic acid, succinic acid, diethylene glycol, 1,4-butanediol, 1,6-hexanediol and/or diethylene glycol.

25. Polyurethane according to claim 17, obtainable by a process comprising reacting the polyester and an isocyanate endcapped diol component, the ratio of polyester endgroups to isocyanate groups being at least two, followed by reacting the resulting prepolymer with water.

26. Polyurethane according to claim 25, based on a copolyester of lactide and ε-caprolacton containing 5 to 95, preferably 40-60 % of units of lactide and 5 to 95, preferably 40-60 % of units of ε-caprolacton, based on number.

27. 1,4-Butanediol, 1,6-hexane diol, or diethyleneglycol based diol component having a uniform blocklength, said component being an XYX reaction product of diol (X) and 1,4-butane-diisocyanate (Y).

28. Process for the preparation of a biomedical polyurethane according to claim 17, wherein the

diol component is reacted with the reaction product of at least two moles of diisocyanate and the polyester.

29. Process for the preparation of a biomedical polyurethane according to claim 28, wherein the diol component is reacted with the reaction product of at least two moles of diisocyanate and the polyester.

30. Process for the preparation of a biomedical polyurethane according to claim 17, wherein the random copolymer is reacted with the reaction product of at least two moles of diisocyanate and the diol component.

31. Implants based on the biomedical polyurethanes according to claim 17, having a porosity of 50 to 99 vol. %.

32. Use of a polyurethane according to claim 17, as biodegradable polymer implant in meniscus reconstruction.

33. Biomedical polyurethane having a phase separated morphology, comprising soft segments of polyester and/or polyether components and hard segments, said hard segments consisting of diol component having a uniform block length, and wherein the diol component on the one hand and the polyester and/or polyether components on the other hand, have been linked by diisocyanate, preferably an aliphatic diisocyanate. --.

REMARKS

The foregoing amendment is made to conform the claims in the application to that amended in the

International Preliminary Examination Report and to delete multiple dependent claims.

Respectfully submitted,

01 December 2000

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I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, **Box PCT**, Washington, D.C. 20231.

Signature of person making certification

Peter L. MICHAELSON
Name of person making certification

(POLYGANICS1PREAMD/88:ca)

Title: Biomedical polyurethane, its preparation and use.

The invention is directed to biomedical polyurethanes and the use thereof in various applications.

Biomedical polyurethanes (PUs) have been used for a wide range of applications. Examples include nerve guides, meniscal reconstruction materials, artificial skin and artificial veins.

For these applications, usually commercially available polyurethanes are used. These materials frequently exhibit good mechanical properties but an important disadvantage is that they contain aromatic diphenylmethane diisocyanate (MDI). MDI based polyurethanes are known to release carcinogenic and mutagenic products on degradation. Furthermore, they often show low resistance to tearing. A high resistance to tearing is important to prevent sutures from tearing out of a biomaterial. The development of new medical grade polyurethanes with good mechanical properties is therefore highly desirable.

Further an important aspect of the biomedical polyurethanes is the requirement that they can be processed into porous shaped bodies, e.g. as implants.

In the development of the novel materials of the invention, first porous 50/50 copoly(ε-caprolactone/L-lactide) materials were used for the reconstruction of meniscal lesions. They showed a very good adhesion to the meniscal tissue and, therefore, a good healing of the meniscal lesion. The mechanical properties of this copolymer resemble the mechanical properties of polyurethanes because of the high molecular weight and the presence of crystallisable L-lactide sequences. The polymer had, however, certain drawbacks. First, the degradation rate was somewhat too high. New meniscal tissue, the so called fibrocartilage, is formed after an induction time of 10 to 20 weeks.

Second, due to the very high molecular weight of the polymer a maximum concentration of 5% could be reached. This resulted in very low compression moduli of porous materials. For the ingrowth of fibrocartilage higher moduli were needed. Finally, the L-lactide crystals, which are still present after 8 years of in-vitro degradation, may induce an inflammatory reaction since cells cannot digest them unlike poly(ε-caprolactone) and polyglycolide crystals.

To avoid lactide crystallinity, an amorphous 50/50 copoly(ε-caprolactone/85,15 L,D-lactide) was used for the production of nerve guides. Due to the absence of crystals, however, this polymer showed swelling upon degradation. Therefore, the focus was put on the synthesis of ε-caprolactone and L-lactide based polyurethanes. The urethane hard segments crystals are likely to be small and susceptible to enzymatic degradation. In addition, by making an ε-caprolactone and L-lactide based PU the biocompatibility may be improved.

When the copolymer was simply chain extended with diisocyanates, the mechanical properties of the resulting polymer were poor due to the absence of a phase separated morphology. Phase separated morphologies can be reached when an isocyanate terminated polyol is chain extended with a diamine or diol resulting in a polyurethane urea and polyurethane respectively. However, the L-lactide and ε-caprolactone based prepolymer showed a deviant behavior with respect to chain extension using a diamine and diol. It appeared that the prepolymer was susceptible to aminolysis and transesterification unlike ε-caprolactone and glycolide/trimethylene carbonate prepolymers.

The invention is directed to novel biomedical polyurethanes, suitable for implants, not having the disadvantages discussed above.

Further it is an aspect of the invention to provide a novel intermediate for this polyurethane, as well as a novel way of producing the polyurethane.

In a first aspect the invention is directed to novel biomedical polyurethanes, based on diisocyanate linked polyester (co)polymer and diol components, said diol component having a uniform block-length.

According to a preferred embodiment, the polyurethane may be represented by the following formula:

$$-(A-B-C-B)-_n$$

wherein the B denote diisocyanate moieties, A denotes a polyester moiety, C denotes a diol moiety and n is the number of recurring units.

In a most preferred embodiment the polyurethane consists of repeating units of the following formula

$$\{C(O)-N-R_1-N-C(O)-O-D-O-C(O)-N-\ R_1-N-C(O)-O-E-O\}_n,$$

wherein R_1 is an n-butylene moiety, D is a polyester moiety, E is an n-butylene diol, an n-hexylene diol or a diethylene glycol based moiety and n indicates the number of repeating units.

With respect to the above formulae it is to be noted that they represent the recurring units of the polyurethane. The endgroups are not represented thereby. The nature of the endgroups will vary according to the type of (co)polyester and diol, as well as with the production process.

Further preferred embodiments of the invention are indicated in the dependent claims.

The products of the present invention show a good balance between the properties necessary for use thereof in biomedical applications, such as good modulus, tensile strength and compression modulus. It has been found possible to process these materials into porous implants by salt-leaching and freeze-drying, resulting in a material having macropores in the range of 150 μm to 300 μm. The material can

also be produced in situ in an extruder, even in combination with generating macropores in situ.

As has been indicated above, the conventional methods of producing polyurethanes may result in transesterification and aminolysis, with the consequence that the material has insufficiently balanced properties. More in particular the uniformity of block-length gets lost, resulting in loss of phase separation. The consequence thereof is that the mechanical properties deteriorate to a level below that which is acceptable for numerous biomedical applications.

An important feature of these polyurethanes is that they owe their good mechanical properties to the phase separated morphology. Because the soft segments (e.g. polyesters, polycarbonates or polyethers) are chemically incompatible with the hard segments (urethane, urea or amide moieties) phase separation occurs. The hard segments crystallize and form strong hydrogen bonds with other hard segments resulting into physical cross-links.

The behavior of these polyurethanes is in strong contrast with other polyurethanes often applied. A well-known example is polyurethanes in which 2 different, chemically incompatible, soft segments (e.g. polyesters and polyethers) are coupled by a diisocyanate. An example thereof is disclosed in US-A 4,2844,506. In this case, also a certain extent of phase separation will occur, but these materials do not owe their mechanical properties to the ability of the urethane functionality to form hydrogen bonds but to the contribution of entanglements and phase separation between the different soft segments. The reason why the urethane functionalities can not contribute to the mechanical properties of the material is that the urethane moieties are too small to crystallize and form hydrogen bonds.

Polyurethanes with a micro-phase separated morphology frequently exhibit good mechanical properties and are generally easy to process due to the relatively low melting point.

Mechanical properties of polyurethane ureas are usually even better resulting from the increased crystallizability and hydrogen bonding ability of the urea moieties. The polymers, however, frequently have melting points that are close to the degradation temperature, leading to a small processing window.

The polymers of the present invention, contain long urethane-based hard segments of uniform size. This results into a system wherein the hard segments have increased crystallizability and hydrogen bonding ability compared to "classical" polyurethanes. The mechanical properties are comparable to those of polyurethane ureas. However, the melting point is still rather low which makes processing relatively easy.

It should be noted that the uniformity of the urethane-based hard segments is the crucial factor for the mechanical properties of the materials. The preferred method for the synthesis of these polyurethanes should therefore be the reaction of the diol component with an excess of diisocyanate followed by reaction with the macro-diol (e.g. polycaprolactone or copolymers of L-lactide and caprolactone). In this process, trans-esterification of the soft segment with the chain extender is avoided, resulting into hard segments of uniform size.

As has been indicated above, the polyurethane of the invention comprises in the most general form diisocyante linked diol and polyester, more in particular linear random copolyester, components. The nature of the diol component is very important, especially with respect to the uniformity of the block-length. The diol and the (linear random co)polyester are connected to each other by diisocyanate, more in particular 1,4-butane diisocyanate.

The polyurethane of the present invention can be prepared by different processes. In a first process the diol component, i.e. the butanediol, hexaneddiol or diethylene glycol, or the reaction product of two molecules of the said

diol with 1,4-butanediisocyanate (BDO-BDI-BDO), is reacted with an isocyanate terminated polyester, i.e. the reaction product of the random polyester with an excess of BDI (BDI-polyester-BDI). By selection of the reaction conditions (temperature, time, catalyst, and the like) the molecular weight of the polyurethane may be selected.

In the alternative the diol component is end-capped with the BDI and reacted with the random copolyester.

According to a further method it is possible to end-cap the polyester with the isocyanate endcapped diol component resulting (in the case of a dihydroxy terminated polyester) in a prepolymer of the following composition:

OCN-E-NH-C(O)-D-C(O)-NH-E-NCO

This prepolymer can subsequently be reacted with water to yield a polyurethane urea according to the invention. This process provides the possibility to generate porous materials in situ, for example by mixing the prepolymer with salt and water, and letting the material react for some time at a suitable temperature. After leaching the salt from the material a porous polyurethane urea has been obtained, whereby part of the pores are provided by the salt and part by the CO_2 generated in the reaction of the prepolymer with the water.

The reactions between the various components are carried out under the conditions known to be suitable for the preparation of polyurethanes.

These processes all result in a useful biomedical polyurethane, having the advantageous properties cited above. It is to be noted that the use of an isocyanate endcapped diol has preference, especially in case the polyester component has the tendency to transesterify.

After the preparation of the base material it is possible to process it further, e.g. from a solution in an organic solvent such as dioxane, into shaped materials. For some applications it is useful to have a porous structure. This can be obtained by the method as described in De Groot

et al, Use of biodegradable polymer implants in meniscus reconstruction, Colloid Polym. Sci., 1990, **268**, 1073-1081. In case of the use of the polyurethane of the invention in meniscus reconstruction, it is useful to have porosities of 50 to 99 vol.%.

The diol component to be used in the present invention has to meet the requirement of uniform block-length. In practice this will mean that at least 90%, preferably at least 98% of the diol component molecules will have the same block-length. Suitable diol components can be based on 1,4-butanediol, 1,6-hexanediol or diethylene glycol. It is possible to use the diol as such, but it is also possible to use a reaction product of a diisocyanate (e.g. 1,4-butanediisocyanate) and two molecules of the diol (BDO-BDI-BDO). Optionally one may end-cap this reaction product with two molecules of BDI, resulting in a five-block, that can be used in the reaction with the linear random copolyester.

The polyester to be used in accordance with the invention will preferably be linear, more in particular be a random copolyester, and will have reactive endgroups. These endgroups may be hydroxyl or carboxyl. It is preferred to have a dihydroxy terminated copolyester, but hydroxy-carboxyl or dicarboxyl terminated copolyesters can also be used. The nature of the endgroups is determined by the type of comonomers, the amounts thereof, the type of starter (if used), and the reaction conditions. It is to be noted, that the molecular weight of the polyurethane in the present invention is not so crucial for obtaining the necessary mechanical properties, as is the case in the prior art. Accordingly, lower molecular weights often suffice.

Suitable monomers for the polyester are the cyclic monomers that can be polymerised under ring-opening polymerisation conditions. Examples are lactides, glycolides, trimethylene carbonate and/or ε-caprolacton. Preferred are lactide (D, L, D-L, meso) and ε-caprolacton. More in

particular a linear random copolyester having about equimolar amounts of ε-caprolacton and L-Lactide is preferred. Other possibilities include polyesters based on succinic acid and ethylene glycol or 1,4-butanediol, or on (co)polyesters of lactic acid. In case the polyester has to be linear, it can be prepared using a difunctional component (diol) as starter, but in case a three or higher functional polyol is used, star shaped polyesters may be obtained.

The conditions for preparing the polyesters are those known in the art.

The invention is now elucidated on the basis of the examples.

Experimental

Materials

L-lactide and ε-caprolactone were obtained from Hycail bv. (Noordhorn, The Netherlands) and used after standard purification. The catalyst stannous octoate ($SnOct_2$) was obtained from Sigma Corp. USA and used directly from the supplier. 1,4-Butane diisocyanate (DSM, Geleen, The Netherlands) was distilled under reduced nitrogen pressure; 1,4-butanediol (BDO, Acros Organics) from 4Å molecular sieves, dimethyl sulfoxide (DMSO, Acros Organics) from CaH_2.

Prepolymer synthesis

For the 50/50 L-lactide and ε-caprolactone, 20 gram of L-lactide (0.14 mol) was mixed with 16 gram ε-caprolactone (0.14 mol) under nitrogen atmosphere. 1.70 gram butanediol (18.87 mmol) and 40 mg stannous octoate were added as initiator and catalyst respectively. The mixture was polymerized for 24 hours at 130°C. ^{1}H-NMR showed complete conversion.

Block synthesis

The isocyanate terminated urethane block (BDI/BDO/BDI) was prepared by reaction of butanediol with a six-fold excess of butanediisocyanate at 80°C without catalyst for 5 hours. The excess diisocyanate was removed by washing with dry hexane.

The hydroxyl terminated urethane block (BDO/BDI/BDO) was prepared by mixing butanediisocyanate with a six-fold excess of butanediol at 80°C without catalyst, for five hours. The excess butanediol was removed by washing with dry acetone.

Polymerization

The prepolymer (50/50 ε-caprolactone/L-lactide) or the diisocyanate end-capped prepolymer was dissolved in DMSO. The chain extender butanediol or block were dissolved in DMSO. The chain extender solution was added drop wise to the prepolymer solution under mechanical stirring. The total polymer concentration after chain extension was 5 w/w% in the case of butanediamine, 30 w/w% in the case of the isocyanate terminated block and 50 w/w% for butanediol and the hydroxyl terminated block.

Characterization

Intrinsic viscosities were measured using a Ubbelohde viscometer.

Calorimeter studies were carried out with a Perkin Elmer DSC 7 calorimeter. The scanning rate was 10°C per minute.

^{1}H-NMR (200 MHz) was used to characterize the blocks.

Tear strength and hysteresis were determined.

Table 1

	Prepolymer	chain-extender
a	Isocyanate terminated prepolymer*	BDO
b	Prepolymer*	BDI/BDO/BDI
c	Isocyanate terminated prepolymer*	BDO/BDI/BDO

*50/50 L-lactide/ε-caprolactone 2000

When the butanediisocyanate terminated prepolymer was chain extended with a BDI-BDO-BDI block (table 1, b), a polymer with an intrinsic viscosity of 1.0 dl/g could be made. The DSC thermogram of the polymer is shown in figure 1. The mechanical properties of the products based on a-c (table 1) are presented in table 2.

Table 2

[η] (dl/g)	Modulus (MPa)	Tensile Strength (MPa)	Strain at break (%)	Tm (°C)	ΔH (J/g)	Tg ((°C)	Permanent Deformation (%)
1.8	12	12	750	53	5.5	-9	13.5
1.0	60	23	640	50, 92	8.6, 4.6	-21	13.5
2.0	62	44	560	49,112	2.3, 16	-5	10.0

These experiments show that the method b of table 1 provides products with better mechanical properties, than method a.

The role of the uniformity of the hard segments has also been demonstrated by the following example:

Polycaprolactone (M=2000) was end-capped with an excess of 1,4-butanediisocyanate. The excess of diisocyanate was removed by distillation. The resulting macro-diisocyanate was chain-extended with the BDO.BDI.BDO block. The resulting

polyurethane had an intrinsic viscosity of 2.00 dL/g and a modulus of 70 MPa.

When polycaprolactone (M=2000) was chain-extended with a BDI.BDO.BDI.BDO.BDI block, a polyurethane of identical composition was obtained. However, in this case trans-esterification reactions of the chain-extender with the polycaprolactone soft segement were avoided. This resulted into a polymer with an intrinsic viscosity of 1.00 dL/g and a modulus of 105 MPa. The lower viscosity of the polymer can be explained by the lower reactivity of the BDI.BDO.BDI.BDO.BDI block compared to the BDO.BDI.BDO block. However, the modulus has significantly increased. This is a result of the uniform hard segments. Hard segments of uniform size are more crystalline and thus more difficult to disrupt.

The absence of a melting endotherm at 60 °C provides additional evidence that by this method trans esterification reactions were avoided.

Claims

1. Biomedical polyurethane based on diisocyanate linked polyester polymer and diol components, said diol component having a uniform block-length.

2. Biomedical polyurethane according to claim 1, having the following formula:

$$\{A\text{-}B\text{-}C\text{-}B\}_n$$

wherein the B denotes diisocyanate moieties, A denotes a polyester moiety, C denotes a diol moiety and n is the number of recurring units.

3. Biomedical polyurethane according to claim 1 or 2 consisting of repeating units of the following formula

$$\{C(O)\text{-}NH\text{-}R_1\text{-}NH\text{-}C(O)\text{-}O\text{-}D\text{-}O\text{-}C(O)\text{-}NH\text{-}R_1\text{-}NH\text{-}C(O)\text{-}O\text{-}E\text{-}O\}_n,$$

wherein R_1 is an n-butylene moiety, D is a polyester moiety, E is an n-butylene diol, an n-hexylene diol or a diethylene glycol based moiety and n indicates the number of repeating units.

4. Polyurethane according to claim 1-3, wherein E is diol or an XYX reaction product of diol (X) and 1,4-butane-diisocyanate (Y).

5. Polyurethane according to claim 1-4, wherein the blocklength is the same for at least 90%, more in particular at least 98% of the diol units.

6. Polyurethane according to claim 1-5, wherein the polyester is based on a polyester prepared by ringopening polymerisation, preferably a random copolyester.

7. Polyurethane according to claim 6, wherein the random copolyester is a copolyester of lactide, glycolide, trimethylene carbonate and/or ε-caprolacton.

8. Polyurethane according to claim 1-6, wherein the polyester is based on lactic acid, succinic acid, diethylene glycol, 1,4-butanediol, 1,6-hexanediol and/or diethylene glycol.

9. Polyurethane according to claim 1-8, obtainable by a process comprising reacting the polyester and an isocyanate endcapped diol component, the ratio of polyester endgroups to isocyanate groups being at least two, followed by reacting the resulting prepolymer with water.

10. Polyurethane according to claim 7, based on a copolyester of lactide and ε-caprolacton containing 5 to 95, preferably 40-60 % of units of lactide and 5 to 95, preferably 40-60 % of units of ε-caprolacton, based on number.

11. 1,4-Butanediol, 1,6-hexane diol, or diethyleneglycol based diol component having a uniform blocklength, said component being an XYX reaction product of diol (X) and 1,4-butane-diisocyanate (Y).

12. Process for the preparation of a biomedical polyurethane according to claim 1-9 or 11, wherein the diol component is reacted with the reaction product of at least two moles of diisocyanate and the polyester.

13. Process for the preparation of a biomedical polyurethane according to claim 1-9 or 11, wherein the random copolymer is reacted with the reaction product of at least two moles of diisocyanate and the diol component.

14. Implants based on the biomedical polyurethanes according to claim 1-10, having a porosity of 50 to 99 vol.%.

15. Use of a polyurethane according to claim 1-10, as biodegradable polymer implant in meniscus reconstruction.

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Claim 16

16. Biomedical polyurethane having a phase separated morphology, comprising soft segments of polyester and/or polyether components and hard segments, said hard segments consisting of a diol component having a uniform block length, and wherein the diol component on the one hand and the polyester and/or polyether components on the other hand, have been linked by diisocyanate, preferably an aliphatic diisocyanate.

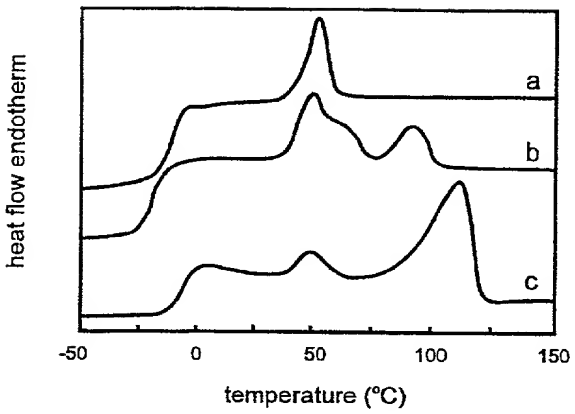

Figure 1. *DSC thermogram of different ε-caprolactone and L-lactide based polyurethanes. a: Butanediisocyanate terminated copolymer prepolymer, chain extended with butanediol. b: Copolymer chain extended with butanediisocyanate end-capped butanediol block. c: 1,4-Butanediisocyanate terminated copolymer prepolymer, chain extended with butanediol end-capped 1,4-butanediisocyanate block.*

Declaration and Power of Attorney Patent Application (Design or Utility)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: "Biomedical polyurethane, its preparation and use".

the specification of which

☐ is attached hereto

x was filed on December 1, 2000, as application serial no. 09/701,622 and or PCT International Application number PCT/NL99/00352 and was amended on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information know to me to be material to patentability as defined in 37 C.F.R.§1.56.

I hereby claim foreign priority benefits under 35 U.S.C.§119(a)-(d) or 35 U.S.C.§365(b) of any foreign application(s) for patent or inventor's certificate, or 35 U.S.C.§365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate of PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)		
Number 98201868.1	Country EP	Day/Month/Year Filed 5 June 1998
Number	Country	Day/Month/Year Filed
Number	Country	Day/Month/Year Filed

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below:

Prior Provisional Application(s)	
Serial Number	Day/Month/Year Filing Date
Serial Number	Day/Month/Year Filing Date
Serial Number	Day/Month/Year Filing Date

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s), or under 35 U.S.C. §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in 37 C.F.R.§1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

Prior U.S. or International Application(s)		
Serial Number	Day/Month/Year Filed	Status (patented, pending, abandoned)
Serial Number	Day/Month/Year Filed	Status (patented, pending, abandoned)
Serial Number	Day/Month/Year Filed	Status (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C.§1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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I hereby authorize them or others whom they may appoint to act and rely on instructions from and communicate directly with the person/organization who/which first sends this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instructed otherwise.

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